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RESEARCH REPORT 49
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ABSTRACT

The number of ova produced by American shad (*Alosa sapidissima*) based on samples of five fish from each of six Atlantic coast rivers was found to range from 209,000 to 616,000 ova per year. Hudson River shad produced fewer ova by size and St. Johns River shad produced more ova by size than did shad from the other four rivers. Statistical evidence is presented to show that the six ovarian samples per fish used to estimate total ova production can be reduced without impairing the accuracy of the total ova production estimate.

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Since 1950 the Fish and Wildlife Service, under the sponsorship of the Atlantic States Marine Fisheries Commission, has been engaged in a coastwise investigation to determine the causes of decline in, and the means of rehabilitation of, the American shad (*Alosa sapidissima*). In the course of this investigation it is valuable to have estimates of survival rates. The basing point for these estimates is the total number of eggs laid in a given spawning stream, which in turn is calculated by multiplying the estimated number of female fish in the spawning escapements by the average number of eggs laid per female. Reliable data on egg production are obviously requisite to the calculations.

Lehman (1953) estimated the annual fecundity of 22 shad from the Hudson River to range from 116,000 ova in the smallest fish to 468,000 ova in one of the larger fish. Prior to his study, shad were generally reported to produce an average of only 30,000 ova annually, based on the quantity of eggs obtained by spawn-takers in shad hatcheries. The investigation initiated by Lehman was continued by the author to determine whether ova production by shad in other Atlantic coast rivers is similar to that of shad in the Hudson River. In addition, a statistical evaluation was made to discover whether the sampling method used by Lehman to determine ova production could be simplified without affecting the accuracy of ova-production estimates.

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ESTIMATING OVA PRODUCTION

Method Used

Ova production was estimated for five shad from each of the following rivers: The Hudson in New York, Potomac in Maryland, Neuse in North Carolina, Edisto in South Carolina, Ogeechee in Georgia, and St. Johns in Florida.

Ovaries were sampled and ova counts were made, following Lehman's[1] (1953) methods:

> The two ovaries from each fish were weighed to the nearest milligram. Excess moisture was removed as consistently as possible by blotting the surface of the ovaries with paper towels before the weights were taken. A small cross-sectional sample (including a portion of the surrounding membrane) of approximately 1 gram was removed from the anterior, central, and posterior regions of each ovary. The six samples were individually weighed to the nearest milligram, each was teased apart . . . the eggs were counted . . . the counts were adjusted to represent a sample size of 1 gram . . . the total number of eggs for each fish was calculated from the sample-unit mean and the total weight of the ovaries.

Maturing ova and anlagen for the succeeding year were separated by the difference in cell diameters (Lehman 1953). To preclude the possibility of obtaining partially spent females, ovaries were taken only from fish collected early in the season or below their spawning areas. Fork length, total weight and date of capture were recorded for all fish (table 1). In addition age was determined for all specimens using the method described by Cating (1953).

[1] Ova-production estimates by length, weight, and age class for the five Hudson River shad examined in this study were sufficiently close to Lehman's 1953 regression lines based on 22 Hudson River fish to show that his method was being duplicated.

Estimated Ova Production

Estimates of ova production for individual shad from the six rivers sampled ranged from 209,000 to 616,000 ova (table 1). The Hudson River shad sampled in 1955 produced fewer ova by size than shad from the other rivers. Highest ova production occurred in the St. Johns River sample at the southern extremity of the range of shad where small fish (14.5 to 17.5 in. fork length) produced considerably more ova than the larger fish (17.5 to 19.5 in. fork length) sampled from the Hudson River. There was a broad overlap in the ranges of ova production by size in the intermediate rivers. Shad from the St. Johns River were captured earlier in their ova-maturation cycle than were shad from the other rivers. This is indicated by small ovaries and a large number of ova per gram sample (table 1).

COMPARISON OF OVA COUNTS BY LOCATION OF SAMPLE

The numbers of ova found in the six ovarian samples from each fish examined in this study were averaged and the mean used to estimate the ova production of the individual shad. Reduction in the number of sample units required from one fish would be desirable if it could be accomplished without significantly affecting the final estimate of ova production. A comparison of the sample unit counts, first, between paired ovaries (the two ovaries from one fish) and second, between locations within paired ovaries, would establish the relation of ova numbers per sample unit to each other in each fish. These two comparisons can be made simultaneously using an analysis of var-

Date of capture	Fork length (in.)	Weight (oz.)	Age (yr.)	Ovary weight (gm.)	Number of ova per 1-gram sample in—						Mean number ova		Total number ova (thousands)
					Section of left ovary			Section of right ovary			In central locations	Per gram	
					Anterior	Central	Posterior	Anterior	Central	Posterior			
Hudson:													
Apr. 20, 1955	17.4	48	5	223.000	1,002	946	980	1,018	977	1,095	961	1,003	224
Do	18.4	58	5	317.335	785	829	722	833	845	751	837	794	252
Do	19.0	63	[1] 6	284.620	1,171	1,041	975	1,204	1,096	985	1,069	1,079	307
Do	19.1	63	5	234.300	1,245	1,142	1,054	1,254	1,201	1,062	1,171	1,160	272
Do	19.5	65	[1] 7	259.300	853	795	848	818	769	756	782	807	209
Potomac:													
Apr. 17, 1952	16.5	42	4	123.902	2,290	2,362	2,120	2,502	2,439	2,550	2,401	2,377	295
Do	18.1	51	5	173.500	1,582	1,553	1,519	1,536	1,595	1,451	1,574	1,540	267
Do	19.0	75	6	289.800	1,578	1,583	1,323	1,644	1,537	1,128	1,560	1,466	425
Do	19.2	55	4	225.775	1,369	1,381	1,296	1,393	1,406	1,279	1,393	1,356	306
Do	19.9	83	6	254.105	2,352	2,163	1,864	2,230	2,043	1,738	2,103	2,065	525
Neuse:													
Jan. 30, 1953	17.6	64	4	111.005	3,843	3,811	3,604	3,796	3,947	3,858	3,879	3,810	423
Do	18.0	63	4	232.555	2,086	2,132	1,875	2,143	1,868	1,787	2,000	1,982	461
Do	19.0	74	6	215.640	2,317	2,039	1,964	2,047	2,006	2,082	2,023	2,076	448
Do	19.6	96	6	259.145	2,184	2,133	2,015	2,320	2,143	1,857	2,138	2,109	547
Do	19.7	77	5	181.900	3,079	2,923	2,754	3,185	3,044	2,842	2,983	2,971	540
Edisto:													
Mar. 4, 1955	18.3	57	4	287.275	1,350	1,259	1,057	1,539	1,244	1,075	1,252	1,254	360
Do	18.8	61	5	262.505	1,869	1,759	1,636	1,957	1,718	1,602	1,738	1,757	461
Mar. 6, 1955	18.8	52	5	340.355	1,169	1,134	1,083	1,236	1,127	1,083	1,131	1,139	388
Mar. 15, 1955	19.6	76	5	310.105	1,647	1,655	1,301	1,831	1,573	1,277	1,614	1,547	480
Mar. 4, 1955	19.8	73	6	279.905	1,548	1,302	1,246	1,545	1,318	1,214	1,310	1,362	381
Ogeechee:													
Mar. 23, 1954	18.0	60	4	259.443	1,411	1,449	1,399	1,385	1,344	1,322	1,396	1,385	359
Apr. 4, 1954	18.0	64	4	330.088	1,200	1,239	1,120	1,292	1,180	1,151	1,210	1,197	395
No date	18.7	76	6	300.800	1,636	1,630	1,641	1,707	1,762	1,625	1,696	1,667	501
No date	18.8	68	5	219.225	2,402	2,051	1,968	2,257	2,036	1,787	2,043	2,084	457
Mar. 23, 1954	18.9	68	6	324.730	1,452	1,372	1,323	1,361	1,313	1,273	1,343	1,349	438
St. Johns:													
Jan. 9, 1953	14.5	32	5	67.455	6,660	5,911	5,278	6,387	5,424	5,003	5,667	5,777	390
Do	15.0	34	4	52.540	6,457	6,151	5,845	6,479	6,038	5,591	6,095	6,093	320
Do	16.1	47	5	86.220	5,157	4,972	4,915	5,132	4,818	4,843	4,895	4,973	429
Do	16.6	48	5	94.035	6,358	6,400	6,292	6,400	7,076	6,780	6,738	6,551	616
Do	17.5	55	5	136.610	4,777	4,526	4,262	4,747	4,520	3,992	4,523	4,471	611

[1] Scale had one or more spawning marks (fish had spawned previous year).

iance (two variables of classification, single observation). Such a test was applied to each of the 30 shad collected from the six Atlantic coast rivers. These comparisons showed (1) that one fish each from the Potomac, Neuse, Ogeechee, and St. Johns Rivers contained paired ovaries which differed significantly at the 95-percent level from each other in the number of ova per sample unit; and (2) that the interrelationship of the 1-gram-sample ova counts for each of the three ovarian regions within paired ovaries varied considerably between fish in every river sampled. Table 2 shows the number of fish from each river with significant and nonsignificant differences at the 95-percent level between the 1-gram-sample ova counts from each of the three regions within paired ovaries.

TABLE 2.—Numbers of shad having significant and nonsignificant differences between sample-location counts within paired ovaries

River	Number of fish with—	
	Significant difference between sample locations	No significant difference between sample locations
Hudson	3	2
Potomac	2	3
Neuse	1	4
Edisto	1	4
Ogeechee	2	3
St. Johns	4	1

The mean number of ova per 1-gram sample of ovary for each shad examined was subtracted from each of the six sample-locatic counts from which that mean w derived. If the anterior samp count in the left ovary, for instanc was higher than the mean samp count for that fish a positive valu was obtained and if lower a negati value occurred. These positive ar negative values indicate a gradie in which the anterior sample from given ovary contains more ova tha the mean sample count for th fish, and the posterior sample co tains fewer ova than that mea Averaging the positive and negati values separately for every samp location and for each river, t center-location sample counts a seen to vary less in most cases fro their respective paired ovary mea than do counts from the oth locations (table 3). They usual vary more symmetrically arou the paired ovary means than other location counts. On the ba of these observations, the mean the two center-location cou (table 1) was compared with t mean of the six sample-locati counts from each fish by an analy of variance (a single variable of cl sification). There was no significa difference at the 95-percent le between these means in any of t 30 fish examined. Therefore, t estimated ova production of a given shad could have been ma as accurately by using the mean the center-location ova counts by employing the method used this study.

TABLE 3.—Averages of the deviations in ova counts for each sample-location calculated for five shad from each river

[The mean number of ova per gram sample for a given fish has been subtracted from each of the sample-location counts of that fish giving positive (above mean) and negative (below mean) differences]

Deviation	Number of ova in—					
	Section of left ovary			Section of right ovary		
	Anterior	Central	Posterior	Anterior	Central	Posterior
Hudson:						
Above mean	75	31	42	57	46	92
Below mean	5	35	76	0	27	71
Total deviation from mean	80	66	118	57	73	163
Potomac:						
Above mean	114	64	0	126	60	173
Below mean	87	15	136	3	22	207
Total deviation from mean	201	79	136	129	82	380
Neuse:						
Above mean	112	59	0	195	82	25
Below mean	0	43	147	22	92	192
Total deviation from mean	112	102	147	217	174	217
Edisto:						
Above mean	105	38	0	210	26	0
Below mean	0	32	147	0	26	162
Total deviation from mean	105	70	147	210	52	162
Ogeechee:						
Above mean	113	43	14	80	96	0
Below mean	31	35	61	0	35	107
Total deviation from mean	144	78	75	80	131	107
St. Johns:						
Above mean	434	83	0	358	525	229
Below mean	193	76	255	151	153	471
Total deviation from mean	627	159	255	509	678	700

SUMMARY

1. The annual ova production of shad collected from six Atlantic coast rivers ranged from 209,000 to 616,000 ova. Hudson River shad produced fewer ova by size than shad from the other rivers. The largest number of ova by size was produced by St. Johns River shad.

2. The mean of the two center-location counts from paired ovaries was shown statistically to be as reliable a method of sampling ovaries for estimates of total ova production as the mean of the six sample-location counts taken from paired ovaries in this study.

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